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THE JOURNAL OF GEOGRAPHY

VOL. V SEPTEMBER, 1906 No. 7

THE GREAT FAULT OF CALIFORNIA AND THE SAN FRANCISCO EARTHQUAKE, APRIL 18, '06

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THE earthquake occurred on the morning of April 18 at San José, about 5:13, Pacific Standard time. The morning was calm, clear and pleasant. The barometer in central California stood about normal, while according to the weather map an area of high pressure extended over northern California, moving in the direction of Idaho.

The shock came without premonition of any sort, no jars preceded it. It was accompanied by violent heaving motions and lasted about forty-eight seconds. Many observers claimed that it was attended by a peculiar roaring rushing noise, somewhat resembling that of a train passing through a tunnel to a man standing above the tunnel. On account of the suddenness of the earthquake, the minds of the people were unprepared, so that temporary surprise and wonder gave way in many cases to fear: thus the subsequent minor shocks frequently caused more manifestations of alarm than the original shock.

Up to the present date of writing (May 21) the subsequent shocks have been of almost daily occurrence, but, according to observers in different parts of the field affected, they have varied somewhat in number and intensity. Between 5:13 A.M. and 7:00 P.M. of April 18 no less than 30 shocks were recorded. During the remainder of the month of April they averaged about two daily, while between May 1 and May 19 inclusive but thirteen are reported by Maurice Connell, weather observer of San José, who states that none of these thirteen shocks exceeded twenty seconds in time, while the majority were between five and eight seconds.

Earthquakes have been grouped as regards their origin into two classes:

1. Those connected with volcanic activity.

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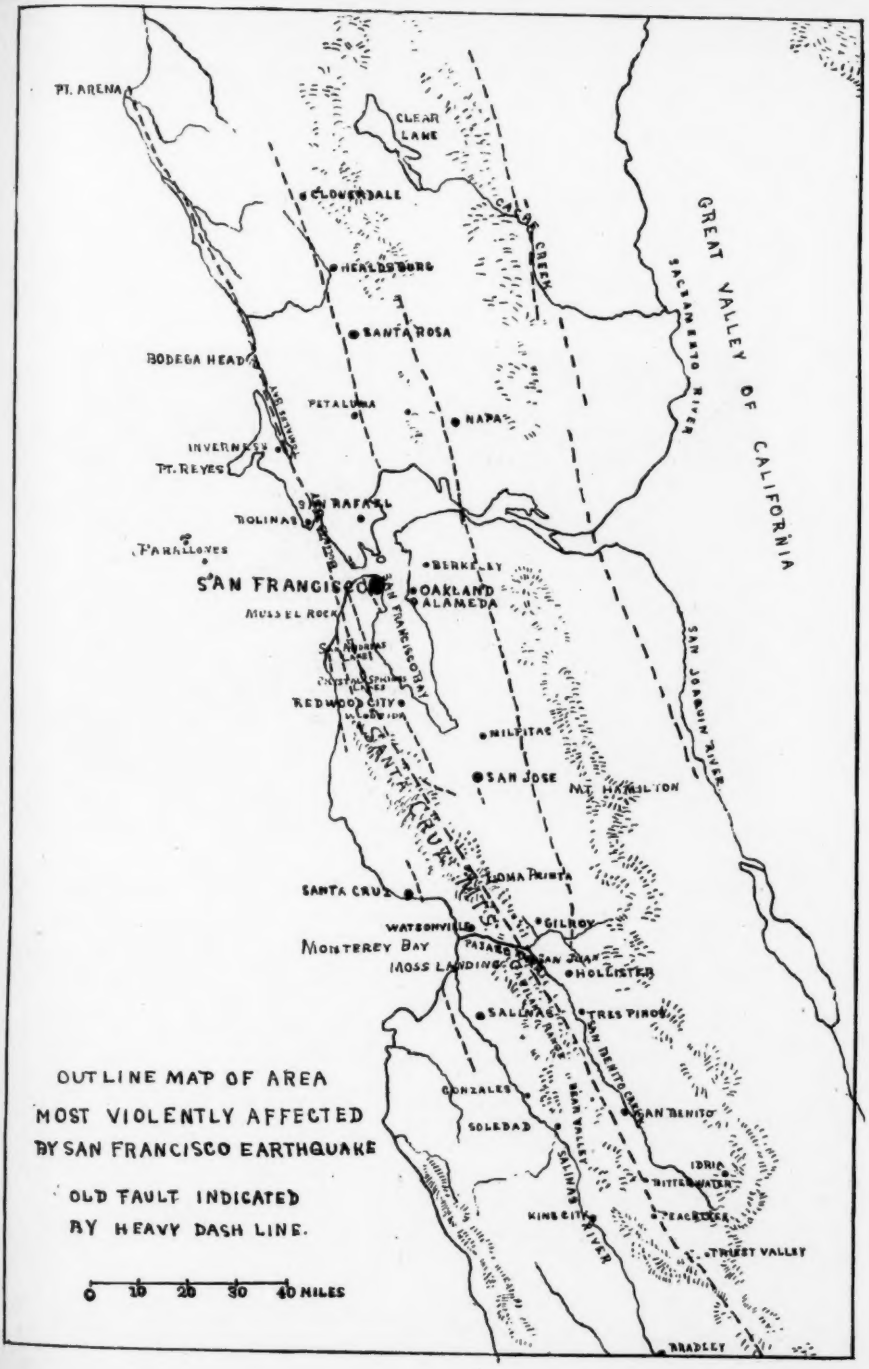
2. Those connected with fractures or slips of the solid crust of the earth.

In the light of the field evidence, not much doubt now exists that this quake belongs to the second class, and for this reason it is easy to see why no preliminary tremors occurred. The stress in mountain building accumulates steadily, while the relief that it finds in the fracture or slipping of the crust is comparatively sudden. On the other hand the shocks connected with volcanic explosions are more likely to yield slight preliminary jars, just as a few bubbles of gas may escape before a body of water reaches the boiling point.

The evidence that the recent disturbance was accompanied by earth displacements is unmistakably clear. Prof. J. D. Whitney while State Geologist for California (1860-1874) called attention to the extremely broken and fractured condition of the rocks of the California Coast Ranges, and every field observer since that day has had opportunity to verify this statement.

Prof. A. C. Lawson of the University of California in his "Geology of the San Francisco Peninsula," 15th Annual Report U. S. Geological Survey, traced many of the faults in the area recently disturbed, and Dr. Branner of Stanford University has indicated others in his work on the Santa Cruz quadrangle now in the hands of U. S. Geological Survey at Washington, D. C. for publication. These two publications embrace the southern part of the area recently most violently disturbed. In this connection it is safe to say that the main topographic features of California are due to faulting. The trend of her valleys and mountain ranges coincides with the direction of her dominant faults, and her river courses in many cases are determined by faulting. Now, as these fractures result in jars it is easy to see that earthquakes have been intimately associated with her geological history.

One of these old fissure lines (see map) which opened afresh along the northern part of its course evidently played an important part in connection with the recent disturbance. This old fault zone is worthy of mention along with the few great fissure lines of the earth, and will now be described. It extends from near Point Arena in Mendocino county southward and very near the coast line through the V-shaped valley containing Tomales Bay, through Bolinas Bay, thence south under the ocean, leaving San Francisco and the Golden Gate to the east, striking the mainland again at Mussel Rock, and in its course through the Santa Cruz Mountains passing through San Andreas Lake, the Crystal Springs Lakes, Woodside, over Black Mountain, along Stevens and Campbell Creeks, Wright's Sta-


PT. ARENA
CLEAR LAKE
CLOVERDALE
HEALDSBURG
SANTA ROSA
BODEGA HEAD
PETALUMA
NAPA
INVERNESS
PT. REYES
SAN RAFAEL
BOLINAS
FAIRFAX
SAN FRANCISCO
BERKELEY
OAKLAND
ALAMEDA
MUSSEL ROCK
REDWOOD CITY
MILPITAS
SAN JOSE
MT. HAMILTON
SANTA CRUZ
LOMA PRIETA
WATSONVILLE
GILROY
MONTEREY BAY
MOSS LANDING
HOLLISTER
SALINAS
TRES PINOS
GONZALES
SOLEDAD
SAN BENITO
IDRIA
KING CITY
PEACHTREE
PRIEST VALLEY
BRADLEY
GREAT VALLEY OF CALIFORNIA
SACRAMENTO RIVER
SAN JOAQUIN RIVER
SAN FRANCISCO BAY
SANTA CRUZ MTS.
BEAR VALLEY
SALINAS RIVER
OUTLINE MAP OF AREA
MOST VIOLENTLY AFFECTED
BY SAN FRANCISCO EARTHQUAKE
OLD FAULT INDICATED
BY HEAVY DASH LINE.
0 10 20 30 40 MILES

tion, Skyland and Loma Prieta to a little south of the Pajarro river, crossing this river near the town of San Juan. Along this distance of about 200 miles there is evidence of a slip or dislocation of the crust of the earth, which accompanied the earthquake of April 18. The zone of maximum destruction follows this line and extends out from it on either side for a few miles.

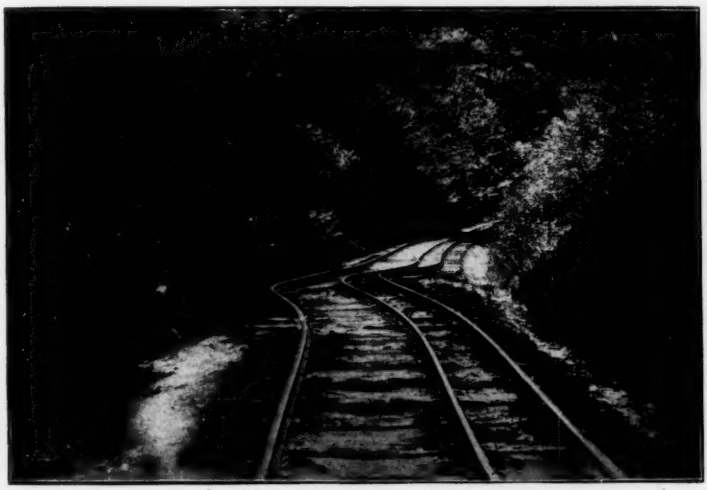
South of Chittenden, near San Juan, this old fault zone passes to the east of the towns of San Juan and Hollister, following a continuous line

Road Near Summit of Santa Cruz Mountains Above Wright's Station on Morrell Ranch. The Lateral Displacement Here is About Four Feet.

of drainage in the eastern foothills of the Gavilan range of mountains, thus skirting the western side of the San Benito Creek Valley. Crossing the mouth of Willow Creek it extends south between Bear Valley and San Benito Valley. It passes west of the town of San Benito, southerly through Dry Lake Valley, Rabbit Valley, Bitterwater Valley, Priest Valley and the Carisa plains, San Luis Obispo Co. South of this its trend seems to be to the southwest of the Mohave Desert, along the northeastern slope of the San Gabriel mountains, through Cajon Pass, the Colorado Desert, and to the Colorado river and the Gulf of California. Its north and south extent is not less than six hundred miles. It connects in a continuous line an interesting series of structure valleys, and has been associated with several well-known historic California earthquakes.*

*Dr. H. W. Fairbanks had recognized this old earthquake zone by its peculiar topography and had lectured

The zone has not been determined by a single fracture line, but is rather the result of a series of fractures along a dominant line of weakness. The rocks on either side are usually much crushed or broken. It is further characterized by ridges and unusual depressions which can in no way be accounted for by erosion. The fractures have also resulted in the accumulation of an unusual water supply difficult to explain except on the hypothesis of a fault. Even in the dry regions of the South we have along this zone in winter a series of small lakes or ponds. The evidence



Contorted Rails, a Result of Compression Due to the Earthquake, Near Aldercroft on Narrow Gauge Railway over Santa Cruz Mountains.

of faulting is also shown in the relations of the rocks themselves on either side of the fault. Along the line of this fault rocks in a vertical range have been observed from the basal complex of metamorphic schists and granites up through Cretaceous, Tertiary and Pleistocene formations. Uulike some of the few great fault lines of the earth this one has continued in its activity from prehistoric times down to the present. Thus this fissure, which has played an important part in the development of the California coast ranges, is to-day opened anew at least along the northern part of its extent.

Erosion has naturally rubbed out much of the fresh evidence of former

on it before the Academy of Sciences, San Francisco, previous to the earthquake of April 18th. He has traced it practically throughout its entire length and states that it is not yet clear whether or not the fault extends further south than the western base of the San Bernardino Range in San Bernardino County.

faulting along this old fissure line. The crack itself is not open to view, nor can the slickensided surfaces even be seen in many instances. The fault scarp, as is usual in the case of old faults, has been worn back some distance from the original fracture line. The fissures have in this way been filled and the region covered with several feet of soil. It is therefore difficult to observe the amount of actual bed-rock movement in the present disturbance. The surface material has been broken, however, along this already determined line, and the dislocation amounts in places to at least twenty feet. The main movement is lateral, or horizontal, and is shown by the shifting of fences, water pipes or mains, broken-off roots

Showing a Fence Laterally Displaced by Fissure Movement Near Woodside, Santa Cruz Mountains. Displacement Nearly Six Feet.

of trees, dislocated roads, dams, and streamlets. Water pipes, fences or lines of trees for example, which cross the fracture line are broken across and displaced laterally from a few inches to several feet. Thus an extra length of fence is needed here and there for repairs; while to compensate, the missing panel is crowded in somewhere else along the line. The effect of this surface compression and distension on the rock below the surface can better be imagined than discerned. Large trees along the fracture zone are in some instances uprooted, houses rent in twain, the parts separating in opposite directions. In one observed instance a barn near Woodside was located immediately over the fracture, the ridge pole being parallel

with the fracture line. The barn split longitudinally and one side was moved along about five feet with reference to the other side.

Mr. C. S. Downes of Berkeley who has just investigated the reopened fissure from Bolinas to Inverness writes: "I found half a dozen east-west fences that were displaced from four to twenty feet. The peninsula to the west has moved north anywhere from three to twenty feet. The crack looks as though a large plow had been over the ground and left an immense furrow. In some cases there is a few inches of vertical displacement. At Inverness it is fifteen to eighteen inches along a secondary crack." Mr. Downes confirms the story of the loss of a cow on the Shafter Ranch that fell head foremost into a fissure and disappeared, all but her tail. The writer has not observed a lateral displacement along the reopened fissure through the Santa Cruz Mountains to exceed eight and a half feet. Observers from the north have reported that a lateral displacement of from ten to twenty feet is not unusual, while as a rule the west or seaward side has become elevated with reference to the east side. This elevation has not been reported to exceed three or four feet. On the other hand the reverse is true in many cases along the southern end of the fissure line, where, in San Mateo and Santa Cruz counties the east side is elevated with reference to the west side. The lateral displacement near Pajarro is about one and a half feet; along toward Pt. Arena it reaches about twenty feet.

It is now confirmed that north of Pt. Arena in Mendocino County the town of Fort Bragg was destroyed and that villages along the coast in Humboldt County suffered severely. This would indicate that the fault entering the ocean near Pt. Arena probably continued north indefinitely a short distance to the west of the coast line.

It was at first conjectured that the centre of disturbance was near San Francisco. Later evidence seemed to indicate that it was further north along the coast. Some have intimated that the fissure may be connected with some volcanic outburst in the Pacific Ocean, Behring Sea, or in Alaska. No sulphurous or other fumes indicating a connection with volcanic activity have been observed, and it seems reasonable to predict that the centre of disturbance will prove to be connected with the axis of the fissure already described, which extends below the surface of the earth to an unknown depth.

The shock was intense enough to break off the trunks and branches of large trees, such as the tall redwoods; and literally to shatter the rock adjacent to the fissure into thousands of pieces. These cracks frequently extend from the main fissure line in an irregular network, so that hundreds

of cracks may be observed in the space of a few rods. There is a lack of uniformity in the character and development of cracks along the fracture zone, being best developed in the case of hard, dry, compact rock material, while moist, soft loose rock shows little or no displacement. It seems highly probable that the surface displacement is not a true index of the bed-rock displacement, and that where the surface material is of a nature to admit of free internal adjustment, a comparatively large deep-seated

San José High School, Typical of Destructive Effects on Brick Buildings.

displacement of the bed rock may not be indicated at all at the surface. Often the surface of the fissure zone resembles a huge plowed furrow or newly made road. Closer inspection reveals often an irregular network of cracks running obliquely to the trend of the fracture zone, just as glass or other brittle substance may be broken diagonally when subjected to a side-wise torsion beyond its breaking strength.

While the disturbance appeared to be greatest along the axis of the fault line running through the Santa Cruz mountains and north along the coast to near Pt. Arena the damage in the valleys to the east and west was great. The Salinas Valley to the west was shaken considerably, as

was the valley region to the east, extending from Hollister past Santa Rosa to the Russian River. No damage is reported south of Tres Pinos except at Priest Valley, where chimneys were thrown down and fissures in the ground reported. It is clear that all along the fissure line for a distance of about twenty miles on either side, extending from near Hollister to Pt. Arena, and still further north, embracing the western part of Humboldt County, the intensity of the movement was greatest. Toward the Great Valley of California and the Sierra Nevada Mountains the shock was perceptibly diminished. Reports from towns along the foothills of the Sierra Nevada Mountains indicate that the shock there was evident to the senses, but that it was slight and comparatively simple in its motions. The minor vibrations there had evidently become dissipated or blended with the fundamental vibration. It was felt as far south as Los Angeles and north into Oregon. On the east it was felt as far as Nevada. Beyond these limits it was recorded on seismographs throughout the world.

Within the area of maximum intensity the earthquake behaved in a somewhat freakish manner when judged by the resulting damage. The destruction of buildings, however, seems to depend, on the one hand, on the soundness of construction, and, on the other, on the firmness of the bed rock foundation. Re-surveys in San Francisco show that property lines are considerably displaced where the land is loose or "made," while on the hills little or no dislocation is observed. On the rocky island of Alcatraz, just north of San Francisco, in Golden Gate, the shock was very slight and accompanied by no destruction. The cities of Santa Rosa, San José, and Salinas, built on loose bottom land, suffered severely. In Redwood City the public buildings are on the flood plain of a slough and are practically demolished. At Bolinas the only houses saved were those built on solid rock foundations. Agnew's Asylum, Moss Landing, Stanford University, Spreckle's Sugar Mill, were all badly wrecked, their foundations being in loose alluvial material.

Evidence of change of altitude above mean sea level as well as of latitude and longitude will have to rest upon accurate surveys.

Near Pescadero natural illuminating gas is reported to have escaped from fissures made in the ground, but during subsequent shocks the amount that escaped steadily decreased. Landslides were abundant, especially in the Santa Cruz Mountains, where the topography is more rugged. One slide, a few miles from Wright's Station, involved eight to ten acres of ground. At Bolinas and Inverness buildings were toppled over into the sea and a near by train of cars was thrown over. Near Milpitas along the Coyote Creek artesian water gushed out of cracks and holes in the

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ground, making temporary fountains several feet high, bringing up silt and forming cones about the outlet, as shown in photograph. Similar outpourings of water are reported from the Salinas valley. In some cases artesian wells stopped flowing, but in general the water level was raised, so that many ordinary wells overflowed. The water in most cases was more or less muddy.

The burning of San Francisco, with the loss of several hundred lives, was the most disastrous consequence of the earthquake and this was very directly connected with this old fault line. The water supply on which the city depended was derived from numerous lakes developed along this old fissure zone. The water mains in some instances followed along the fault itself and crossed it in several places. It was the displacement and

Silt Cones Along Earthquake Crack Near Milpitas Formed by Gushing Out of Artesian Water at Time of Earthquake.

destruction of these water mains brought about by the slip that made it impossible to save the city from destruction by fire.

The disturbance had the effect of lowering the general level of alluvial land and opening in it numerous cracks. In several instances in the Santa Clara Valley water pipes in wells dug through the uncompacted and unconsolidated valley sands, gravels and clays showed, after the shock, a foot or more of the pipe above the general surface of the ground. The alluvium thus became more compacted and compressed, just as jarring a bag of grain causes it to occupy less volume. This compacting of the rock

Showing Series of Lakelets Along Old Fault Zone West of Town of San Benito, San Benito County.

material was probably a factor in bringing about a general rise of the water level in ordinary wells as well as an increased flow from artesian wells and springs.

It does not seem clear whether the discontinuous, but somewhat linearly arranged surface cracks extending for several miles along the water courses of the Santa Clara Valley, as well as in other places remote from the main fissure zone, indicates a fault in the bed rock below, or whether this fracturing is wholly dependent on the nature of the surface rock. It is but natural to assume that one main fissure movement should be accompanied by others in neighboring parts of the field, just as one ice crack is usually accompanied

by others making a succession of ice blocks which adjust themselves finally to the pressure conditions. It is undoubtedly true, however, that many of the cracks developed in alluvial material remote from the main fissure line are due to the jarring effect radiating out from along the axis of the main fissure. They thus represent the effects of the quake and are in no way connected with its cause. In general the main cleft or fissure is not open except where it follows along a sloping or inclined surface.

In some cases fissures opened and closed tightly again with a force sufficient to cause a surface ridge of a few inches along the fissure line, just as ice is observed to bulge up along the line of ice cracks where subjected to a horizontal pressure. In other cases blocks of earth fell down into the cracks from the sides for a few feet, as is shown by the photograph of fissures from near Milpitas. This seems to explain the occurrence of depressions along the old earthquake zone, as shown in the photograph from near the town of San Benito, a common feature already mentioned, along this old earthquake zone. Erosion of course would quite soon obliterate the fissures. In other cases the cracks that were at first very deep, so that the bottom could not be seen, were observed to close up gradually in the course of a few days.

In the light of the evidence it was a shock of considerable intensity, and in view of the wide area affected, the length of the surface fissure and the complexity of the motions will rank with the few great earthquakes of the world. It is clear that buildings solidly constructed were able to withstand the shock even if located along the fracture zone. Had the displacement, however, been chiefly vertical instead of horizontal, the destruction of life and property would have undoubtedly been very much greater, in which case, too, since the old fissure zone extends out to sea, destructive tidal waves would have been generated. The horizontal movement in this case probably accounts for the absence of a tidal wave. In any event such a wave could not enter the Golden Gate to the destruction of life in the cities on the borders of San Francisco Bay because the narrow inlet tends to prevent extremes of tidal level within the bay.

Past history would indicate that California is not likely soon to be freed from earthquakes. Her solidly built missions are now nearly all in ruins. The people, however, unhampered by Oriental fatalism or religious frenzy, cannot afford to lose the important lesson and nothing should deter them from building stable structures even at the expense, if necessary, of beauty, for elements of beauty in modern architecture too often are allied with elements of weakness. At this date of writing, however, the subsequent shocks are becoming less frequent, the fears of

the people are subsiding, and much consolation is had in the fact that rocks once faulted or broken are incapable of resisting any large accumulation of strain, but will yield forthwith. Hence no quakes of unusual magnitude are likely soon to occur even though the hidden forces which bring about fissures and accompanying shocks are still likely to be operative.

N. B. The wr ter has since observed a parallel fissure about two miles to the east of the main fissure, passing through Baden and Merced Lake. North of Baden this fissure is evident for about half a mile and here shows a lateral displacement, the west side moving north with reference to the east side. This would indicate that while the lateral displacement along the main fissure line already described was north with reference to the east side, this movement was relative and that both sides moved north with referenee to points still further east.

THE VALPARAISO EARTHQUAKE.

Three earthquakes of great intensity, closely following each other, took place about 8 P. M., August 16th, and practically annihilated our flourishing city. Immediately numerous fires resulted and spread to a conflagration which finished much of the destruction originated by the earthquakes. There was an inadequate supply of water and the firemen were utterly helpless to cope with the flames. The gas and electric light establishments were also deranged, so that except for the light from burning buildings the town was left in darkness. The consternation was terrible, the populace being utterly panicstricken.

The military authorities took charge of the place immediately after the disaster, and the behavior of officers and troops has been excellent. Martial law was promptly proclaimed, and still continues, looters and incendiaries being shot mercilessly. The first apprehensions of famine and thirst were soon allayed by the exemplary manner in which the authorities commandeered food supplies and established strict discipline in respect of the water service.

Now that some calm has returned to the city it is possible to gather fairly reliable information. The casualties have been very heavy. The mortality is fully 2,500 and the injured 4,000 to 5,000 cases.

As to material losses, it is impossible to get at any close estimate yet of the "value" that has been destroyed. But our own personal observations, corroborated by other opinions, justify us in stating that not a single structure of any sort has escaped without some earthquake damage. In fact, we would summarize the damage to property in Valparaiso as:

Absolutely wrecked and ruined by earthquake, 50 per cent.

Destruction finished by conflagrations, some immediately on the heels of the earthquakes and others in the succeeding four to five days, 25 per cent.

Buildings with damages ranging from great to trifling, and many of which will have to be razed, 25 per cent.

Expressed this way, the figures will help to convey a graphic idea of the exceptionally severe nature of the calamity.

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THE CHARACTERISTICS OF THE ZONES
I.—THE TROPICS*

By ROBERT DeC. WARD
Harvard University

Synopsis

General: climate and weather.—Temperature.—The seasons.—Physiological effects of heat and humidity.—Pressure.—Winds and rainfall.—Land and sea breezes.—Thunderstorms.—Cloudiness.—Intensity of sky-light and twilight.—Climatic subdivisions:—I. The equatorial belt.—II. Trade wind belts.—III. Monsoon belts.—IV. Mountain climate.

General: Climate and Weather. The so-called "Torrid Zone" has been variously bounded. Its limits have been set at the tropics (lat. 23½°); at the mean annual isotherms of 68°, which also correspond closely with the poleward extension of palms; and at the polar margins of the trade winds. The dominant characteristic of this great belt, embracing but a little less than one-half of the earth's surface, is the remarkable simplicity and uniformity of its climatic features. This simplicity is reflected in the striking regularity in the recurrence of the ordinary weather phenomena. The tropics lack the proverbial uncertainty and changeableness which characterize the weather of the higher latitudes. In the torrid zone, weather and climate are essentially synonymous terms. Periodic phenomena, depending upon the daily and annual march of the sun, are dominant. Non-periodic weather changes are wholly subordinate. The succession of daily weather changes is even more regular, and the distribution of the climatic elements is even more uniform over the tropical oceans than over the lands. In special regions only, and at special seasons, is the regular sequence of weather temporarily interrupted by an occasional tropical cyclone. These cyclones, although comparatively infrequent, are notable features of the climate of the areas in which they occur. Generally bringing very heavy rains, and thus locally increasing the total annual precipitation by a considerable amount, they yet cause no marked temperature changes such as those which are the common accompaniments of

* This article and the two which are to follow (II. The Temperate Zones; III. The Polar Zones) are intended to give an outline of the more important climatic characteristics of the zones in a simple form, which may be helpful to teachers of geography. The writer has naturally drawn largely from Hann's standard works, the *Handbuch der Klimatologie* (2d ed., 1897, Vol. II) and the *Lehrbuch der Meteorologie* (2d ed., 1906). The data for the curves which were drawn expressly for this article, were taken from the *Lehrbuch*.

The following books were also used: Bartholomew's *Atlas of Meteorology*, Edinburgh, 1899. W. M. Davis: *Elementary Meteorology*, Boston, 1902. W. Köppen: *Klimalehre*, Leipzig, 1899. F. Ratzel: *Anthropogeographie*, 2d ed., Stuttgart, 1899. A. Supan: *Grundzuge der Physischen Erdkunde*, 3d ed., Leipzig, 1903. W. Trabert: *Meteorologie und Klimatologie*, Leipzig and Vienna, 1905. W. J. van Bebber: *Hygienische Meteorologie*, Stuttgart, 1895. A. Woeikof: *Die Klimate der Erde*, Jena, 1887.

extra-tropical cyclones. The devastation produced by one of these storms often affects the economic condition of the people in the district of its occurrence for many years.

Temperature. The sun is always well up in the sky. The length of day and night varies little. Hence the mean temperature is high, it is very uniform over the whole zone, and there is little variation during the year. The mean annual isotherm of 68° is a rational limit at the polar margins of the zone, and the mean annual isotherm of 80° encloses the greater portion of the land areas, as well as much of the tropical oceans. The isotherms are thus far apart. The warmest latitude circle for the year is not the equator, but latitude 10° north. The highest mean annual temperatures, shown by the isotherm of 85°, are in Central Africa, in India, the north of Australia and Central America, but, with the exception of the first, these areas are small. Massowah, on the Red Sea, has an annual mean of over 86°. The temperatures average highest where there is little rain. In June, July and August there are large districts in the south of Asia, and north of Africa with temperatures over 90°. Winds blowing out from these heated deserts are uncomfortably hot and dusty.

Over nearly all of the zone the mean annual range of temperature is less than 10°, and over much of it, especially the oceans, it is less than 5°. At Equatorville, in the interior of Africa, on the Congo, the mean annual range is only a little over 2°; at Iquitos. (lat. 3.7°S.) in Peru, it is 4.3°. Even near the margins of the zone, where the seasonal differences are greatest, the ranges are less than 25°, as at Calcutta, Hong Kong, Rio de Janeiro and Khartoum. The mean daily range is usually larger than the mean annual. Thus at Equatorville, the former is about 14.5°. It has been well said that "night is the winter of the tropics." The differences between the maximum and minimum temperatures of the year near the equator are not much greater than the daily range. Over an area covering parts of the Pacific and Indian Oceans from Arabia to the Caroline Islands and from Zanzibar to New Guinea, as well as on the Guiana coast, the minumum temperatures do not normally fall below 68°, and over much of the torrid zone as a whole they do not fall below 59°. Towards the margins of the zone, however, the minima on the continents fall to or even below 32°. Maxima of 115° and even over 120° (122°) occur over the deserts of northern Africa. A district where the mean maxima exceed 113° extends from the western Sahara to northwestern India, and over Central Australia. Near the equator the maxima are therefore not as high as those in many so-called "temperate" climates. The greater portion of the torrid zone is a water surface, and marine con-

ditions are therefore typical for most of it. These tropical oceans show remarkably small variations in temperature. The "Challenger" results on the equator showed a daily range of hardly 0.7° in the surface water temperature, and Schott determined the annual range as 4.1° on the equator; 4.3° at latitude 10°, and 6.5° at latitude 20°. It has been clearly pointed out by Hann that the uniform distribution of temperature throughout the year—the dominant feature of the tropics—results not only from (1) the small variation in insolation and in the length of the day, but also (2) from the great extent of the zone, which makes it impossible for cold winds from higher latitudes to penetrate into the lower latitudes; (3) the oblique course of the trades, which are well warmed on their indirect road towards the equator; (4) the slight nocturnal cooling, where the air is damp and vapor is readily condensed and (5) the great extent of the tropical oceans, which stamps so much of the zone with a marine climate.

The Seasons. In a true tropical climate, seasons, in the temperate zone sense, do not exist. The variations in temperature throughout the year are so slight that the seasons are not classified according to temperature, but depend on rainfall and the prevailing winds. The life of animals and plants in the tropics, and of man himself, is regulated very largely, in some cases almost wholly, by rainfall. Agriculture prospers, or fails, according to the sufficiency and punctual appearance of the rains. After a long dry season, when the rains come, there is an extraordinarily sudden awakening of the parched and dusty vegetation. Where, on the other hand, there is abundant moisture throughout the year, a tree may at the same time be carrying buds, blossoms and ripe fruit. Vegetation under these conditions has been well called non-periodic. Although the tropical rainy season is characteristically associated with a vertical sun (i. e., summer), that season is not necessarily the hottest time of the year. The temperature is usually somewhat lower under the clouds. The rainy season often goes by the name of winter for this reason, and also because the weather is dull. The time of the maximum temperature is also controlled by the rainy season. Towards the margins of the zone, with increasing annual ranges of temperature, seasons in the extra-tropical sense gradually appear.

Physiological Effects of Heat and Humidity. Tropical monotony of heat is associated with high relative humidity except over deserts and in dry seasons. The air is therefore muggy and oppressive. The high temperatures are disagreeable and hard to bear. The "hot-house air" has an enervating effect. Energetic physical and mental action are often difficult or even impossible. The tonic effect of a cold winter is lacking. The most humid districts in the tropics are the least desirable for persons from

higher latitudes; the driest are the healthiest. The most energetic natives are the desert-dwellers. The monotonously enervating heat of the humid tropics softens, so that man becomes sensitive to slight temperature changes. A fall of temperature to within a few degrees of 70° seems to some tropical natives almost unbearably cold, and certain African tribes sleep on clay banks heated inside by fires, although the mean temperature of the coldest month is over 70°. In drier climates such changes are more easily borne. People from latitudes where marked changes of temperature are common often become soft and susceptible in the tropics. The intensity of direct insolation, as well as of radiation from the earth's surface, may produce sunstroke and heat prostration. "Beware of the sun" is a good rule in the tropics.

Pressure. The uniform temperature distribution in the tropics involves uniform pressure distribution. Pressure gradients are weak. The annual fluctuations are slight, even on the continents. The diurnal variation of the barometer is so regular and so marked that, as von Humboldt said, the time of day can be told within about fifteen minutes if the reading of the barometer be known. Even severe thunderstorms do not overcome the regular diurnal march of the pressure, but the approach of tropical cyclones can be foretold by the pressure changes.

Winds and Rainfall. Within the tropics there are both heavy rains and large districts of very deficient precipitation. Along the barometric equator, where the pressure gradients are weakest, is the equatorial belt of calms, variable winds and rains—the doldrums. This belt, with its actively ascending damp, hot air, offers exceptionally favorable conditions for abundant rainfall, and belongs among the rainiest regions of the world, averaging probably about one hundred inches. The rainfall is so heavy that the salinity of the surface waters of the oceans is actually less than in the latitudes of the trades. Here the sky is prevailingly cloudy; the air is hot and oppressive; heavy showers and thunderstorms are frequent, chiefly in the afternoon and evening. Here are the dense tropical forests of the Amazon and of equatorial Africa. Here frost and drought need not be feared. This belt of calms and rains, of variable width, shifts north and south of the equator after the sun. It is dreaded by seamen because sailing vessels are apt to have long delays in crossing it. In striking contrast are the easterly trade winds, blowing between the tropical high pressure belts and the equatorial belt of low pressure. Of great regularity, embracing about one-half of the earth's surface, and adding greatly to the uniformity of tropical climates, the trades have long been favorite sailing routes because of the steadiness of their winds, the infre-

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quency of storms, the brightness of their skies and the freshness of the air. The trades are subject to many variations. Their northern and southern margins shift north and south after the sun; at certain seasons they are interrupted often over wide areas near their equatorward margins, by the migrating belt of equatorial rains and by monsoons; near lands they are often interfered with by land and sea breezes; in certain regions they are invaded by violent cyclonic storms. The trades, except where they blow on to windward coasts or over mountains, are drying winds. They cause the deserts of northern Africa, eastern Asia, Australia, South Africa and southern South America. The monsoons on the southern and eastern coasts of Asia are the best known winds of their class. In the northern summer the southwest monsoon, warm and sultry, blows over the latitudes from about 10° north to and beyond the northern tropic, between Africa and the Philippines, giving rains over India, the East Indian Archipelago and the eastern coasts of China. These winds reach a storm velocity over the Arabian sea. In winter the northeast monsoon, the normal cold-season continental outflow from Asia, combined with the northeast trade, generally cool and dry, covers the same district, extending as far north as latitude 30°. Crossing the equator, these winds reach northern Australia and the western islands of the South Pacific as a northwest rainy monsoon, while this region in the opposite season has the normal southeast trade. Other monsoons are found in the Gulf of Guinea and in equatorial Africa. Wherever they occur, they control the seasonal changes.

The most important climatic phenomenon of the year in the tropics is the rainy season. Tropical rains are in the main summer rains, i. e., they follow as a general rule soon after the "vertical sun," * the rainy season coming when the normal trade gives way to the equatorial belt of rains, or when the summer monsoon sets in. There are, however, many cases of a rainy season when the sun is low, especially on windward coasts in the trades. Tropical rains come usually in the form of heavy downpours and with a well-marked diurnal period, the maximum varying with the locality between noon and midnight. The conditions at Calcutta, as shown in the accompanying data are fairly typical.

* It will be remembered that at all places within the tropics the sun is vertical twice in the year.

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*Diurnal Distribution of Rainfall at Calcutta.**

Midnight—2	A.M.	50	Noon—2	P.M.	111
2-4	A.M.	71	2-4	P.M.	116
4-6	A.M.	65	4-6	P.M.	120
6-8	A.M.	71	6-8	P.M.	128
8-10	A.M.	58	8-10	P.M.	73
10	A.M.—Noon	92	10	P.M.—Midnight	45

Local influences are, however, very important, and in many places night rainfall maxima are found.

Land and Sea Breezes. The sea breeze is an important climatic feature on many tropical coasts. With its regular occurrence, and its cool, clean air it serves to make many districts habitable for white settlers, and has deservedly won the name of "the doctor." On not a few coasts, the sea breeze is a true prevailing wind. The location of dwellings is often determined by the exposure of a site to the sea breeze. For this reason many native villages are put as near the sea as possible. The houses of well-to-do foreigners often occupy the healthiest and most desirable locations, where the sea breeze has a free entrance, while the poorer native classes live in the lower, less exposed and less desirable places. A social stratification is thus determined by the sea breeze.

Thunderstorms. Local thunderstorms are frequent in the humid portions of the tropics. They have a marked diurnal periodicity; find their best opportunity in the equatorial belt of weak pressure gradients and high temperature, and are commonly associated with the rainy season, being most common at the beginning and end of the regular rains. In many places, thunderstorms occur daily throughout their season, with extraordinary regularity and great intensity. Lightning, is, however, reported as very seldom doing any damage. Attention has been called to the fact that the frequent electrical discharges cause the rain water to be relatively rich in nitric acid. This condition, together with the carbon dioxide in the rain water and the high temperature of the same, promotes active and deep rock decomposition. In higher latitudes, where the ground may be frozen part of the year, and where the decomposing action of rain water is less, there is less of this action.

Cloudiness. Taken as a whole, the tropics are not favored with such clear skies as is often supposed. Cloudiness varies about as does the rainfall. The maximum is in the equatorial belt of calms and rains, where the sky is always more or less cloudy. The minimum is in the trade latitudes, where fair skies as a whole prevail.† The equatorial cloud belt moves north and south after the sun. Wholly clear days are very rare in

*Seven year record; expressed in thousandths of the daily mean.

†Supan, *Grundzuge der Physischen Erdkunde*, 3d ed., 1903, Fig. 13, page 53, gives a diagram showing the distribution of rainfall and cloudiness (also of other elements) according to latitude.

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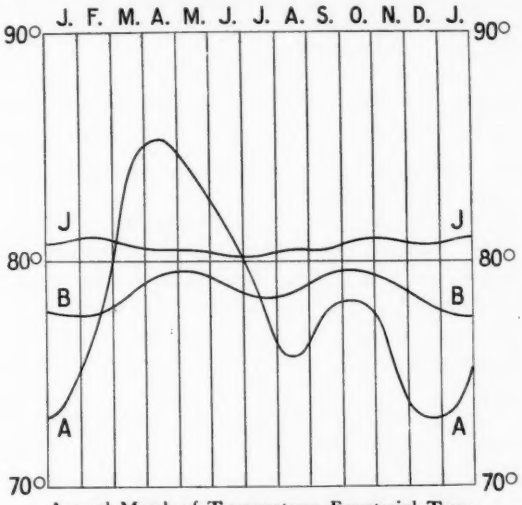
the tropics generally, especially near the equator, and during the rainy season heavy clouds usually cover the sky.

Tropical clouds and rainfall as a whole repeat, in an exaggerated form, the summer conditions of much of the north temperate zone. Broken skies; cumulus and cumulo-nimbus clouds; heavy showers or thunderstorms—these usually characterize the rainy season. Skies clear, or flecked with scattered small cumuli, are typical of the dry season. Wholly overcast, dull days, such as are common in the winter of the temperate zone, occur frequently only on tropical coasts in the vicinity of cold ocean currents, as in Peru and on parts of the west coast of Africa. In these same regions ocean fogs are common.

Intensity of Sky-light and Twilight. The intensity of the light from tropical skies by day is trying, even almost unbearable, to newcomers. The intense insolation, together with the reflection from the ground, increases the general dazzling glare under a tropical sun, necessitating protection of some sort. The far-famed deep blue of the tropical sky is much exaggerated. During much of the time smoke from forest and prairie fires (in the dry season); dust (in deserts) and water-vapor give the sky a pale, whitish appearance. In the heart of the trade wind belts at sea the sky is much more of a deep blue. The beauty of tropical sunrise and sunset, and of the tropical night, have, however, not been overrated. Twilight within the tropics is shorter than in higher latitudes, but the coming on of night is less sudden than is generally assumed. Pechuel-Lösche and others have shown that it is possible, on the Loango coast, to read ordinary print twenty to thirty minutes after sunset.

Climatic Subdivisions. The rational basis for a classification of the larger climatic provinces of the torrid zone is found in the general wind systems and in their control over rainfall. Following this scheme there are these subdivisions: I. The equatorial belt; II. The trade wind belts; III. The monsoon belts. In each of these subdivisions there are modifications due to ocean and continental influences. In general, both seasonal and diurnal phenomena and changes are more marked in continental interiors than on the oceans, islands and windward coasts. Further, the effect of altitude is so important that another class should be added to include IV. Mountain climates.

I. *The Equatorial Belt.* Within a few degrees of the equator, and when not interfered with by other controls, the annual curve of temperature has two maxima following the two zenithal positions of the sun, and two minima at about the time of the solstices. This, which is known as the *equatorial* type of annual march of temperature, is illustrated in the data and curves for the interior of Africa, Batavia, and Jaluit.



Annual March of Temperature: Equatorial Type.
A: Africa, interior. B: Batavia. J: Jaluit, Marshall Islands.

*Table of Mean Monthly Temperatures for Selected Tropical Stations**

	I. Equatorial Type			II. Tropical Type				
	Continental	Insular	Marine	Continental		Monsoon	Insular	
	Africa interior	Batavia	Jaluit, Marshall Islands	Wadi Halfa	Alice Springs	Nagpur	Honolulu	Jamestown
Lat.	8.1°N	6°11′S	5°55′N	21°53′N	23°38′S	21°9′N	21°18′N	15°55′S
Long.	23.6°E	106°50′E	169°40′E	31°20′E	133°37′E	79°11′E	157°50′N	5°43′W
Altitude	1837 ft.	23 ft.	10 ft.	426 ft.	1926 ft.	1093 ft.	49 ft.	39 ft.
Jan.	73.4°	77.5°	80.8°	61.3°	85.6°	68.2°	70.0°	73.6°
Feb.	77.2°	77.7°	81.0°	66.6°	83.3°	73.8°	70.3°	74.7°
Mar.	83.8°	78.4°	80.6°	73.0°	77.9°	83.7°	70.9°	75.9°
April	85.3°	79.3°	80.4°	81.0°	68.5°	90.3°	72.9°	75.0°
May	83.7°	79.5°	80.4°	87.1°	60.6°	94.3°	74.3°	71.8°
June	81.5°	78.8°	80.2°	91.4°	54.0°	85.6°	76.1°	69.4°
July	78.4°	78.3°	80.2°	93.4°	51.8°	80.1°	77.2°	67.6°
Aug.	75.7°	78.6°	80.4°	91.6°	59.4°	80.2°	77.5°	65.7°
Sept.	77.7°	79.3°	80.4°	87.1°	66.6°	80.4°	77.2°	67.8°
Oct.	78.1°	79.5°	80.8°	83.1°	73.4°	78.6°	76.5°	68.9°
Nov.	75.7°	79.0°	80.8°	71.4°	79.7°	72.3°	73.8°	70.5°
Dec.	72.9°	78.1°	80.6°	64.8°	82.8°	66.7°	71.4°	71.8°
Mean	78.6°	78.8°	80.6°	79.3°	70.3°	79.5°	73.9°	71.1°
Range	12.4°	2°	0.7°	32°	33.8°	27.5°	7.6°	10.3°

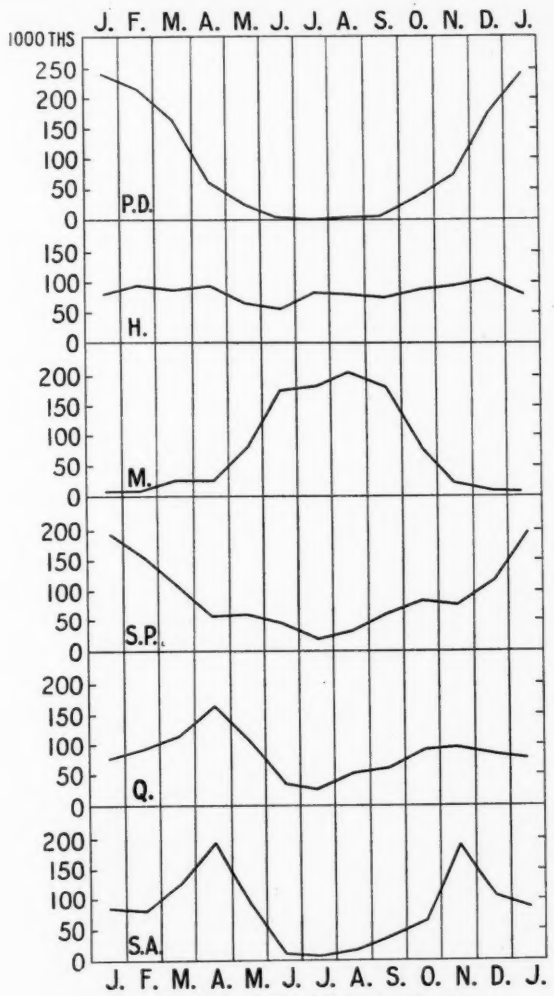
The greatest range is shown in the curve for the interior of Africa; the curve for Batavia illustrates insular conditions with less range, and the oceanic type, for Jaluit, Marshall Islands, gives the least range. At Jaluit the daily maxima for the entire year are between 88° and 91.5° and the daily minima between 75° and 77°. This double maximum is not a universal phenomenon, there being many cases where but a single maximum occurs, as will be seen later.

As the belt of rains swings back and forth across the equator after the sun, there should be two rainy seasons with the sun vertical, and two dry seasons when the sun is farthest from the zenith, and while the trades blow. These conditions prevail on the equator, and as far north and south of the equator (about 10°-12°) as sufficient time elapses between the two zenithal positions of the sun for the two rainy seasons to be distinguished from one another. In this belt, under normal conditions, there is therefore, no dry season of any considerable duration. The double rainy season is clearly seen in equatorial Africa and in parts of equatorial South America. The maxima lag somewhat behind the vertical sun, coming in April and November, and are unsymmetrically developed, the first maximum being the principle one. The minima are also unsymmetrically developed, and the so-called "dry seasons" are seldom wholly rainless. In this equatorial belt the annual range of rainfall is generally below 20%; in the western portion of the Malay Archipelago and on the upper Amazon it is below 10%. In these latitudes, therefore, the distribution of rainfall is not unlike that in extra-tropical latitudes which are under the marine regime of rainfall, there being precipitation at all seasons.

This rainfall type with double maxima and minima has been called the *equatorial* type, and is illustrated in the following data and curves for South Africa and Quito. *

The mean annual rainfall at Quito is 42.12 inches. These double rainy and dry seasons are easily modified by other conditions, as by the monsoons of the Indo-Australian area, for example, so there is no rigid belt of *equatorial rains* extending around the world. In South America, east of the Andes, the distinction between rainy and dry seasons is often much confused. In this equatorial belt the cloudiness is high throughout the year, averaging .7 to .8, with a relatively small annual period. The data and curve following are fairly typical, but the annual period varies greatly under local controls.

*Given to nearest tenths of a degree Fahr.



Annual March of Rainfall in the Tropics.

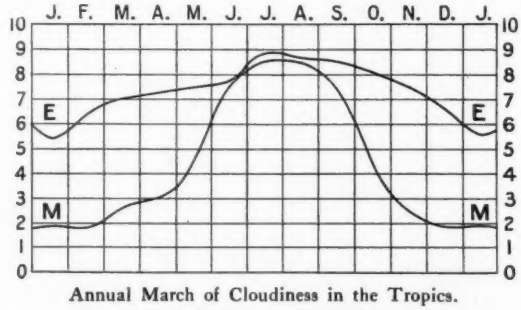
S. A: South Africa. Q: Quito. S. P: Sao Paulo. M: Mexico. H: Hilo. P. D: Port Darwin.

Table Showing Monthly Distribution of Rainfall for Selected Tropical Stations[1]

	Tropics					
	Double Rainy Season Equatorial		Single Rainy Season			
			Margin of Tropics		Trade Rains	Monsoon Rains
			Southern	Northern		
	Southern Africa	Quito	São Paulo	Mexico	Hilo	Port Darwin
Latitude	6°S	Equator	23.5°S	19.4°N	19.7°N	12.5°S
Jan.	86	77	195	7	79	241
Feb.	80	92	156	9	94	215
March	123	115	103	26	86	166
April	195	165	58	26	94	61
May	91	109	60	85	66	23
June	10	35	46	174	55	1
July	7	25	19	180	82	0
Aug.	17	52	31	207	81	2
Sept.	37	60	60	179	73	5
Oct.	61	91	82	79	88	38
Nov.	188	94	74	20	95	72
Dec.	105	85	116	8	107	176

Table showing Monthly Distribution of Cloudiness (in tenths) *in an Equatorial Climate.* (Cameroons; Gaboon. Lat. 3°N, West Africa.)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
5.4	6.3	7.0	7.2	7.4	7.7	8.9	8.6	8.4	8.0	7.4	6.6	7.4



Annual March of Cloudiness in the Tropics.
E: Equatorial Type. M: Monsoon Type.

At greater distances from the equator than about 10° or 12° the sun is still vertical twice a year within the tropics, but the interval between

[1] The figures in this table are thousandths of the mean annual rainfall. In the first column of the table, the average of a considerable number of stations is given.

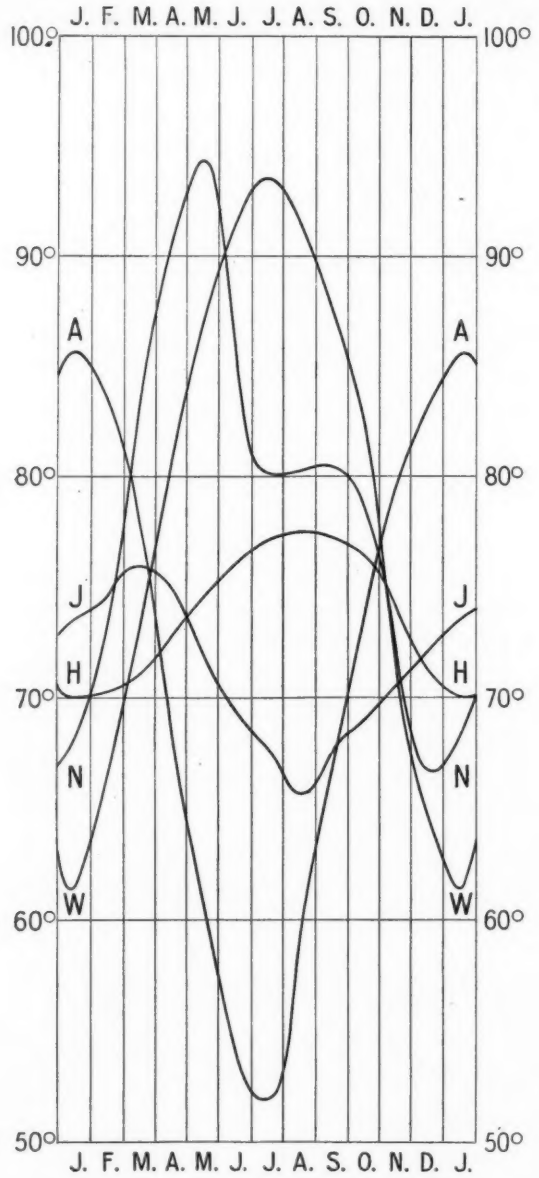
these two dates is so short that the two rainy seasons merge into one, in summer, and there is also but one dry season, in winter. This is the so-called *tropical type of* rainfall[1], and is found where the trade belts are encroached upon by the equatorial rains during the migration of these rains into each hemisphere. It is illustrated in the data and curves for São Paulo, Brazil, and for the city of Mexico (see rainfall table above). The mean annual rainfall at São Paulo is 54.13 inches, and at Mexico 22.99 inches.

The districts of tropical rains of this type lie along the equatorial margins of the torrid zone, outside of the latitudes of the *equatorial* type of rainfall. The rainy season becomes shorter with increasing distance from the equator. The weather of the opposite seasons is strongly contrasted. The single dry season lasts longer than either dry season in the equatorial belt, reaching eight months in typical cases, with the wet season lasting four months. The lowlands often become dry and parched during the long dry trade wind season (winter) and vegetation withers away, while grass and flowers grow in great abundance, and all life takes on new activity during the time when the equatorial rainy belt, with its calms, variable winds and heavy rains, is over them (summer). The Soudan lies between the Sahara and the equatorial forests of Africa. It receives rains, and its vegetation grows actively, when the doldrum belt is north of the equator (May-August). But when the trades blow (December-March) the ground is parched and dusty. The Venezuelan llanos have a dry season in the northern winter, when the trade blows. The rains come in May-October. The campos of Brazil, south of the equator, have their rains in October-April, and are dry the remainder of the year. The Nile overflow results from the rainfall on the mountains of Abyssinia during the northward migration of the belt of equatorial rains.

Simple *tropical* rainfalls, as shown in the above curves, are typical of large areas, but they are not infrequently complicated by association with trade or monsoon rains, as in the West Indies, Central America and India. The true doldrum rains may come along the polar margin of the equatorial low pressure belt, when this belt is moving equatorward, followed by the trades.

The so-called *tropical* type of temperature variation, with one maximum and one minimum, is illustrated in the data given in the table on page 309, and in the accompanying curves for Wadi Halfa, in upper Egypt; Alice Springs, Australia; Nagpur, India; Honolulu, Hawaii, and Jamestown, St. Helena. The effect of the rainy season is often shown in a

[1] Supan calls it the *marginal type* of the tropics.



Annual March of Temperature: Tropical Type.

W: Wadi Halfa. A: Alice Springs. N: Nagpur. H: Honolulu. J: Jamestown, St. Helena.

displacement of the time of maximum temperature to an earlier month than the usual one. During the rains, the temperature is apt to remain constant, as in the case of Nagpur, and of other stations in India, Mexico and the interior of Senegambia. This type of temperature curve is characteristic of most of the tropics outside of the latitudes reached by the equatorial belt.

II. *Trade Wind Belts.* The trade belts near sea-level are characterized by fair weather, steady winds, infrequent light rains or even an almost complete absence of rain; very regular, although slight, annual and diurnal ranges of temperature, and a constancy and regularity of weather which is more truly "temperate" than that of most of the so-called temperate zone. The climate of the ocean areas in the trade wind belts is indeed the simplest and most equable in the world, the greatest extremes—and even these are moderate—being found to leeward of the larger lands, where the continental conditions are carried offshore by the prevailing winds. On the lowlands swept over by the trades, beyond the polar limits of the equatorial rain belt, (roughly between lats. 20° and 30°) are most of the great deserts of the world. These deserts extend directly to the water's edge on the leeward western coasts of Australia, South Africa, and South America. In the two latter regions the desert conditions are further helped by the presence of cold ocean currents offshore. Because of their great extent, these trade wind deserts constitute one of the most important climatic districts in the world.

The ranges and extremes of temperature are much greater over the deserts, especially the continental interiors, than over the oceans of the trade wind belts. Minima of 32° or less occur during clear, quiet nights, and daily ranges of over 50° are common. The midsummer mean temperature rises above 90°, with noon maxima of 110° or more in the non-cloudy, dry air of a desert day. The days, with high dry winds, carrying dust and sand, with extreme heat, accentuated by the absence of vegetation, are disagreeable or even dangerous to life, but the calmer nights, with active radiation under clear skies, are much more comfortable. The nocturnal temperatures are even not seldom too low for comfort in the cooler season, when thin sheets of ice may form. Under the strong insolation by day and the quick cooling by night, rocks in the deserts split and break up. On the whole, however, man is less susceptible to the larger temperature ranges in tropical deserts than to the smaller ones in the equatorial belt, because of the lower relative humidity in the former case. In the trade wind deserts, as in other arid regions, man is nomadic.

While the trades are drying winds as long as they blow strongly over

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the oceans, or over lowlands, they contain a large amount of water vapor and readily become rainy if they are cooled during an ascent over a mountain or highland. Hence the windward (eastern) sides of mountains or bold coasts in the trade wind belts are well watered, while the leeward sides, or interiors, are dry. Mountainous islands in the trades, like the Hawaiian Islands, many of the East and West Indies, the Philippines, Borneo, Ceylon, Madagascar, Teneriffe, etc., show marked differences of this sort. The eastern coasts of Guiana, Central America, southeastern Brazil, southeastern Africa, and eastern Australia are well watered, while the interiors are very dry in the two last-named countries. The eastern highland of Australia constitutes a more effective barrier than that in South Africa; hence the Australian interior has a more extended desert. South America in the southeast trade belt is not well enclosed on the east, and the most arid portion is an interior district close to the eastern base of the Andes where the land is low. Even far inland the Andes again provoke precipitation along their eastern base, and the narrow Pacific coastal strip, to leeward of the Andes, is a very pronounced desert from the equator to about lat. 30°S. The cold ocean waters, with prevailing southerly (drying) winds alongshore, are additional factors in causing this aridity. The Peruvian climatic province is abnormally cool. Highlands in the trade belts are therefore moist on their windward slopes—even in deserts mountains provoke local rainfall, tree growth and local streams—and become oases of luxuriant plant growth, while close at hand, on the leeward sides, dry savannas or deserts may be found. The damp, rainy and forested windward (NE trade) side of Central America was from the earliest days of European occupation left to the natives, while the centre of civilization was naturally established on the more open and sunny southwestern side.

The rainfall associated with the conditions just described is known as the *trade type*. These rains have a maximum in winter, when the trades are most active, this being a departure from the general rule of summer rains in the tropics. In cases where the trade blows steadily throughout the year against mountains or bold coasts, as on the Atlantic coast of Central America, there is no real dry season. The data and curve for Hilo (mean annual rainfall 145.24 inches), on the windward side of the Hawaiian Islands, show typical conditions. While the *tropical* rains are convectional, and therefore prefer the warm season, the trade rains are orographic, and have a winter maximum.

The trade type of rainfall is often much complicated by the combination

with it of the *tropical* type and of the *monsoon* type (see next paragraph). Zanzibar, for example, has its principal maximum of rainfall in April, which is pure *tropical,* and has a secondary maximum in December, which is *trade.* Again, on the lee of highlands which receive a winter maximum on their windward slopes, summer rains may occur at the time when the trade is weakest, and the otherwise long dry season is interrupted by scattering showers. In the Malay archipelago there are complications of equatorial and trade rains; likewise in the West Indies. Trade rains often have a tendency to give precipitation both day and night, while torrid zone rains generally prefer the day.

III. *Monsoon Belts.* In a typical monsoon region, such as that of India, eastern Asia and the adjacent islands, the rains follow the vertical sun, and therefore have a simple annual period much like that of the *tropical* type above described, the dry season coming when the sun is lowest (winter). This monsoon type of rainfall is well illustrated in the data and curve for Port Darwin (mean annual rainfall 62.72 inches) in Australia. This summer monsoon rainfall results from the inflow of a large body of warm, moist air from the sea on to a land area; a consequent retardation of the velocity of the air currents, as the result of friction, and an ascent of the air, the rainfall being particularly heavy where the winds have to climb over high lands. Thus, in India, the precipitation is heaviest at the head of the Bay of Bengal, where Cherrapunji, at the height of 4,455 feet in the Khasi Hills, has a mean annual rainfall of between 400 and 500 inches; along the southern base of the Himalayas (60 to 160 inches); on the bold western coast of the peninsula, (80 to 120 inches and over), and on the mountains of Burmah up to 160 inches. In the rain-shadow of the Western Ghats, the Deccan often suffers from drought and famine unless the monsoon rains are abundant and well distributed, and the decreasing rainfall up the Ganges valley leaves the Indus plain with a deficiency (less than five inches). The prevailing direction of the rainy monsoon wind in India is southwest; on the Pacific coast of Asia, southeast. This monsoon district is very large, including the Indian Ocean, Arabian Sea, Bay of Bengal, and adjoining continental areas; the Pacific coast of China, the Yellow and Japan Seas, and numerous islands from Borneo to Sakhalin on the north and to the Ladrone Islands on the east. Where the seasons are clearly defined in India, they are three in number: a cool, dry season (winter) when northerly trade winds prevail, and when there is little or no rainfall except in the northern provinces, where moderate cyclonic storms occasionally occur; a wet season, sultry and oppressive, with the inflowing southwest monsoon of

summer; and a hot dry season before the beginning of the rains. The beginning of the monsoon rains usually comes suddenly ("burst"), with heavy thunderstorms. A typical temperature curve for a monsoon district is that for Nagpur, in the Indian Deccan, and a typical cloudiness curve is given above, the maximum coming near the time of the vertical sun, in the rainy season, and the minimum in the dry season.

Table showing Monthly Distribution of Cloudiness (in tenths) *in a Monsoon Climate* (Bengal, lat. 23.5°N).[1]

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1.9	1.8	2.6	3.0	4.5	7.5	8.5	8.4	7.5	4.3	2.5	1.8	4.5

In the Australian monsoon region, which reaches across New Guinea and the Sunda Islands, and west of Australia, in the Indian Ocean, over latitudes 0°-10°S, the monsoon rains come with north-west winds in the period between November and March or April. The northern portion of Australia is thus watered by zenithal summer rains, and the southern portions of Sumatra, Borneo and Java are also under the influence of this northwest monsoon. The essential features of the whole Indo-Australian monsoon belt, therefore, are a fairly uniform distribution and small annual range of temperature; and well-marked periodic rains, coming with northwest or southwest winds according to the hemisphere.

The general rule that eastern coasts in the tropics are the rainiest finds exceptions in the case of the rainy western coasts in India and other districts with similar monsoon rains. On the coast of the Gulf of Guinea, for example, there is a small rainy monsoon area during the summer; heavy rains fall on the seaward slopes of the Cameroon Mts. Not far inland, Baliburg shows a double maximum of the equatorial type. Gorée, lat. 15°N., on the coast of Senegambia, gives a fine example of a rainy (summer) and a dry (winter) monsoon. A case of a special kind is the Somali coast, which trends NE-SW and is therefore parallel with both monsoons. Hence at no season can it become very rainy, and mean annual rainfalls of 40 inches are not recorded until the coast takes a turn to the south, at Mombasa.

Numerous combinations of equatorial, trade and monsoon rainfalls are found, often creating great complexity. In the case of Port Darwin the station is near enough to the equator to have two rainy seasons *(equatorial type)* when the sun is vertical, as is frequently the case in the West Indies and Central America in the same latitude. The rainiest month, however, is January, between the two times of vertical sun, but

[1] Five Stations.

during the height of the monsoon, there being a rainy season of four months and a dry season of eight months. The monsoon thus interferes with the typical occurrence of equatorial rains. It is also true that the dry season in monsoon districts is drier than the two dry seasons of the equatorial type. Batavia, on the island of Java, has simple monsoon rains. Buitenzorg, on the same island, has a monsoon maximum in January, two months before the sun is vertical for the first time, and it has a regular tropical maximum of rainfall in October, following the second zenithal position of the sun. The north coast of Ceram, in the Moluccas, has northwest summer monsoon rains, with a maximum in February, while the south coast has winter rains, with the southeast trade. The rainy and dry seasons thus come under different conditions and at opposite times on the two coasts. These two sets of conditions are often very close together, with a divide between them. On the island of Hawaii, Hilo, on the east side, is exposed to the northeast trade and has a winter maximum of rainfall. Kailua, on the lee side, has about one-third as much rainfall, with a summer maximum. The islands of the East Indian archipelago furnish many examples of such curious complications. The eastern coast of Madagascar has southeast trade winds fairly uniformly through the year, while the interior and west coast have a summer maximum—the normal tropical rainfall season.

IV. *Mountain Climate.* In the torrid zone altitude is chiefly important because of its effect in tempering the heat of the lowlands, especially at night. If tropical mountains are high enough, they carry snow the year around, even on the equator, and the zones of vegetation may range from the densest tropical forest at their base to the snow on their summits. The highlands and mountains within the tropics are thus often sharply contrasted with the lowlands, and offer more agreeable and more healthy conditions for white settlement. They are therefore often sought out by residents from colder latitudes as the most attractive resorts. In India, the hill stations are crowded during the hot months by civilian and military officials, and it has been well said that India is ruled from 7,000 feet above sea level. The climate of many tropical plateaux and mountains has the reputation of being a "perpetual spring." Thus on the interior plateau of the tropical Cordilleras of South America, and on the central plateau of tropical Africa, the heat is tempered by the altitude, while the lowlands and coasts are very hot. The rainfall on tropical mountains and highlands often differs considerably in amount from that on the lowlands, and other features common to mountain climates the world over are also noted. But the main emphasis is rightly laid upon the temperature.

XUM

WHAT A CHILD OUGHT TO KNOW AT THE END OF HIS SCHOOL GEOGRAPHY COURSE

By WILLIAM CHARLES MOORE
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WHAT a child ought to know at the end of his school course in geography concerns both the class-room teacher and the supervisor. The supervisor must have the ultimate aim of the course in mind, and, by a close articulation of the different grades, must make unity of work possible. He should also judge of the relative importance of different topics, so that the work as a whole shall be well balanced. But the actual results will depend in great measure upon the kind of work done by the class room teachers.

Different individuals will, of course, expect different results. In fact, there is much diversity of opinion among general superintendents of instruction as to what should be included within the course of study and in what order it should be taught. Notwithstanding these differences, however, a discussion of what may be expected at the end of the school course in geography ought to establish some common ground of greater or less extent.

One of the most fundamental results to be attained is an understanding of the relation of each individual to his surroundings. This is simply what is expressed, of course, in the usual definition of geography. All education is concerned in general in helping humanity adjust itself in relation to its mental and material environment. Geography not only contributes towards this end in a general way, but it also provides special facilities for the interpretation of the conditions which determine the course and progress of the life of the times.

The basis for this interpretation must be derived by a systematic and progressive study of home geography. The lessons learned from the local features and conditions must not end with the fourth grade, however; to insure the results implied in this article, the geographical types of the home locality should be referred to in every grade. He is a good naturalist who knows his own parish, and a good juvenile geographer is one who has begun to realize how the local hills, valleys, plains, streams, coastal forms, and the prevailing conditions of temperature and moisture have influenced favorably or unfavorably the industrial, commercial, and social development of his own particular part of the world.

A recognition of the geographical bearing of current events brings

the work of the schoolroom into a close, vital relation with the affairs of the outside world. From all parts of the globe the daily papers, the current magazines, and the monthly consular reports bring valuable geographical information. These items vitalize and make real the most important topics in geography. This custom of using current information, if practised in every grade, will help the pupil to realize that the text-book does not necessarily contain the latest or most authentic information. It teaches the pupil to use the atlas, the gazeteer and other sources and it helps to establish a habit which, in the years that follow school life, will tend to keep one's stock of geographical information up to date and available.

One of the most apparent aims in the study of geography is some knowledge of the principal physiographic types in their relation to life. Mountains, lofty and snow-capped, with steep irregular sides, attractive as scenic centers, and those worn down and subdued, useful in furnishing lumber, metals, coal, pasture, and possibly farming lands; valleys, steep sided and narrow, of doubtful value for settlements or for lines of travel, and others, broad and open, with slopes so gentle that, in affording both easy means of transportation and suitable sites for cities, they rival the plains of fluviatile, marine, or glacial origin; rivers in different stages of development, some providing natural facilities for moving merchandise and people and others furnishing valuable water power; coastlines that exhibit the principal features of the contact between the land and sea and exemplify the advantages and disadvantages to man of varying degrees of irregularity, —all of these types, which are found throughout the world, are constantly recurring in the different grades and are a source of increasing geographical interest. A comparison of each new example of these different types with those already recognized in the previous grades serves as the very best kind of review. It helps to keep the names and locations of the principal mountain ranges, rivers, plains and coastal forms in mind. At the end of the school course, therefore, it may reasonably be expected that the pupil will have a fair degree of knowledge of the location and characteristics of the principal physiographic features of the world and a keen appreciation of the effect of these factors, individually and collectively, in determining the desirability of the earth for man.

A knowledge of the main facts about climate is another of the more important results to be expected. In every grade from the earliest to the latest, in the geography of the home locality and in the study of distant lands, the prevailing conditions of temperature and moisture are ever-present and important factors. The facts which constitute what is meant

by climate are within the comprehension of every pupil; the explanation of these facts is another thing. To know that water passes into the air in an invisible form is a matter of simple observation and inference; so is the fact that this vapor when cooled sufficiently manifests itself as cloud, fog, dew, frost, rain or snow. A full explanation of the process by which this is brought about is too difficult for the grammar-school pupil, but a knowledge of the facts may reasonably be expected. The effect of latitude and of altitude upon temperature and the modifying influence of the proximity of large bodies of water are elements in the problem of climate which come within the range of the pupil's powers. That the wind is a movement of air caused by difference in atmospheric pressure, which, in turn, may depend upon variations in temperature, is a fundamental fact which leads to an understanding of the planetary circulation of the atmosphere, and finds many illustrations in the work of the different grades. Climate is without doubt one of the most complicated and difficult parts of geography; it is also the most important of the geographic controls. Man has overcome to some extent the limitations imposed by relief and by large bodies of water, but he can never hope, in the open, to defy climatic conditions. Throughout the study of this topic the training in the class-room ought to recognize the importance of making the understanding aid the memory in recalling such matters as the location of the principal heat belts, the circulation of the atmosphere and the distribution of rainfall.

The *facts* connected with the study of what is sometimes called astronomical geography ought to be well in mind at the end of the pupil's course in geography. By some educators the *explanation* of these facts is also attempted. The wisdom of including what is essentially astronomical will depend upon the time at the disposal of the teacher and the proficiency of the class. To introduce the *explanation* of the variation in the length of daylight and darkness and the change in the angle with which the sun's rays strike different portions of the earth at different seasons, in the fifth or sixth grades, or perhaps the seventh grade, as it is frequently done, is almost a waste of time. Facts themselves are matters of observation, pupils of all ages may be expected to see things; the explanation of what is observed, however, demands an exercise of the reasoning powers and this must wait for the development of the pupil's mind. The memorization of the teacher's explanation, expressed though it may be in words of the simplest character, does not necessarily imply understanding. The alternation of day and night is something within the experience of the most elementary pupil and its explanation involves simply turning a globe held in the sunlight. It is taken for granted, therefore, that the rotation of

the earth upon its axis and the attendant consequences will be familiar facts. Other facts, which in themselves are matters of seasonal or even daily occurrence in the lives of the pupils, and which, therefore, everyone ought to know something about upon the completion of the course of study, are the diurnal paths of the sun at the time of the solstices and equinoxes as observed in the home latitude, the variations in the length of daylight and darkness, the diurnal and seasonal ranges of temperature for the locality in which the individual lives and the relation of temperature to length of day and inclination of the sun's rays.

These observations will lead naturally to the memorizing of other facts not within the pupil's own experience, like the position upon the earth's surface of the sun's vertical rays at different times of the year, the consequent location of the Tropics of Cancer and Capricorn, and the seasonal shifting of the heat equator and zones of heat.

The map and the globe are among the most important sources of geographical information. But the usefulness of the globe in showing, among other things, the relative position and size of countries and continents is too seldom recognized, and the school-room map is usually poor. A greater number of facts and relations can be presented at once to the eye by a good map than could be gained by hours of study of lengthy verbal descriptions. To be able to read contour maps of large scale, like those of the U. S. G. S., to interpret the best wall maps intelligently, and to draw simple sketch maps of the continents ought to be among the most valuable results of a school course in geography.

The study of maps means something more than location. Most maps, however, with which pupils become familiar in their school course are not of much use for any other purpose. They show principally the outline of the continent, the boundaries of the political divisions, the location usually of too many cities and little more than the position of the mountains, rivers, lakes and coastal forms. The best maps show variation in altitude by different colors, or a scale of tones of the same color, intensity of relief by hachure lines and differences in the depth of the sea in tints of blue. Upon these maps the continents are presented with the third dimension, not in terms of plane figures. A map which does not show elevation, within a reasonable degree of accuracy, neglects to present an important factor of both relief and climate—the two most fundamental things upon which the usefulness of the earth for the home of man depends.

The familiarity with the map which the pupil ought to carry away with him at the end of his school course is something different from an acquaintance with the names of the capes, bays, peninsulas, the boundaries

or countries and State or the location of capitals and principal cities. Location, by the way, is best learned incidentally. For example, a familiarity with the position of the surface features in one's home locality is gained, not as the result of direct effort with the local map, but by frequently coming into relation with them in the every-day affairs of life. So, too, the location of distant places is learned most effectively and naturally through the frequent associations and comparisons that form the basis of the best teaching. It is not a knowledge of location alone, therefore, which the pupil should possess but the ability to understand from a set of symbols the present or possible future relations of different portions of the earth to man. It is, in brief, the power to read from the map the physiographic and climatic conditions which affect the distribution of the world's population.

A knowledge of latitude and longitude is essential for the intelligent appreciation of any map. These terms ought by constant drill to mean something real and definite to the pupil so that when the formal school work is over the individual will use them easily and naturally. Too often, however, latitude and longitude are abstract things. This method of locating a place is made necessary by the spherical form of the earth. In no other way, in fact, can location upon the earth's surface be accurately determined. Expressing the position of a continent, country or city in terms of latitude and longitude ought to recall the relation of the map to the globe and the location of the place named in the world as a whole.

Throughout the work in geography the human element is a most important factor. The relation of relief and climate to man's occupation of the earth has already been dwelt upon. The life of the world depends not only upon the physical surroundings but also upon the characteristics of the people. One of the results of the school geography course, therefore, ought to be an acquaintance with the characteristics of the different races, states of society, forms of government and leading industries. In this study of the sociological conditions, as in the work with physical features, good examples of types are constantly occurring through the different grades. When the pupil reaches the last year in geography his previous training ought to have provided a good basis for the intelligent study and appreciation of the leading political institutions and the relation of a good government to industrial and commercial conditions.

To summarize: the results to be expected at the end of the course include principally a knowledge of those fundamental things which occur in some form or other in the legitimate work of nearly every grade. Consequently the more characteristic features, as a result of being approached

from different points of view, at different times and in different ways, ought to become almost as familiar to the pupils as the multiplication table. The details of the work, which of course are indispensable for a lucid presentation of the main facts, will, it is expected, be forgotten. Indeed this is as it should be for then there is an opportunity for what is really important and characteristic to stand out in the memory. In general, it may be said that the study of geography in school ought to contribute towards developing the pupil's geographical sense or instinct. It ought to enable the individual to obtain the highest kind of satisfaction out of travel, and it ought to prepare the citizen in a measure to anticipate or predict the geographical possibilities and probabilities of different localities industrially, commercially and as dwelling places. Briefly, the things which have been suggested in the preceding paragraphs are the fundamental facts which form the basis of the geographical part of a good education.

THE IMPROVEMENT OF SCHOOL GEOGRAPHY.

Actual accomplished improvement in school geography can only be brought about by the teachers who perform the class-room work. It is more than gratifying therefore to find such interest in one of the most difficult subjects of the school curriculum that teachers make special efforts to study the subject and the teaching of the subject with a view to making their work more effective.

A Teachers Geography Club, organized several years ago in Boston, has done effective work among a small body of teachers. This year the club finds such interest in the subject that meetings will be held fortnightly. The Geographic Society of Chicago also reports widespread interest in geography among the teachers of that city and a club for the study of geography has recently been formed among the teachers of Buffalo.

All these signs of awakened interest indicate that, in spite of the progress of the last twelve years, teachers recognize that geography teaching is far from being what it ought to be and that improvement is being made so rapidly in the texts and courses of study that constant study is necessary to keep abreast of a subject, which, stagnant for a generation, has recently proved one of the most active subjects in the school curriculum.

XUM

EDITORIAL

NATHANIEL SOUTHGATE SHALER

THE death of Professor Nathaniel Southgate Shaler, on April 10 last, has brought vividly to the minds of many of the geography teachers of the country and to hosts of others the question as to what makes a man or woman a great teacher. The more than five thousand students who had voluntarily come under his influence in his classes, are by their very number a witness to the fact that Professor Shaler was, unlike many teachers, not a mere imparter of information, a hearer of lessons, or a lecturer who slowly and begrudgingly traversed the well worn path of previous years. These students were led to his classes by the tradition that had existed for several college generations that everyone ought to take at least one course with Professor Shaler, "not so much for the subject as for the man." This tradition was founded on the knowledge which gradually grew stronger as the successive classes came and went, that here was a man who taught because he loved to teach, and hence taught well; who was filled with interest in young men, and hence fitted his subject to his hearers and not his hearers to his subject; who had a keen knowledge of human nature that enabled him quickly to fathom the thoughts and feelings of his young friends, and hence to gain their confidence as well as their esteem.

The students who sat under Professor Shaler felt, as they had every right to feel, that their teacher was their friend, who would gladly discuss with them the affairs of their life and give them advice and help from the fullness of his experience at any time. They listened to him as he told them the story of the earth and made it personal, until as the weeks went on they found that they were gaining an insight into the world about them which was not merely something new, but different from anything that could be gained from books or from reading. Many were led, because of their teacher's inspiring leadership, to look further and deeper into the subject and to follow the science of geology as a profession just because their first introduction to the science was made so mind-opening. The large majority went forth from his classes broader in their mental vision, more in sympathy with nature, more keen to analyze the problems of science presented to them daily, and with a deep conviction that they had gained a mental altitude that gave them a broader and more human outlook on the world. These thousands felt, as they heard the sad news of Professor Shaler's death, that they had lost a near personal friend, and that one of

the strongest personalities associated with their memories of their Alma Mater had passed away, and that the college would ever be different to them in subsequent visits.

Those who had come more closely in contact with Professor Shaler, who had been with him day after day for several years, felt that the world had suddenly stopped for a brief moment and that their lives would be different ever afterwards. They could not believe the sad news; and, as they looked back over their many years of friendship and association and analyzed the question as to what it was that made Professor Shaler so dear to them, saw that the growth of their esteem had been through several stages. As youths they were inspired by his wonderful exposition in the class-room, and by his deep love for all that was noble and pure; as the years went on they came to love him because of his breadth of sympathy, his versatility and his nobleness, which could not be appreciated in early acquaintance because their knowledge was not deep enough. Those who knew him longest loved him because of all these qualities and many others that became deeper and richer as the years advanced. Above all and through all shone the deep humanity of the man, evidenced in his every thought, suggestion and act. It was this deep human interest in and sympathy with all phases of life and endeavor that made him a man so far different from his fellowmen and beloved by all who knew him—and many who did not. He was a splendid example of the fact that great teachers are, above all, great men and women, and that the personality of a teacher is a more vital asset than his learning or his training in the ways of teacher. Professor Shaler was a great teacher because he was primarily a broad-minded, big-hearted man, vigorous of speech, keen of mind, quick of action, versatile beyond belief almost, always interested in everything about him however remote or seemingly trivial. He sacrificed his strength in every way in the service of his fellows; but his influence will go on through the generations, by his books and writings, but more especially by the teachings of those he taught to teach, by example. Professor Shaler was very fond of quoting, with deep reverence and feeling, "My master, Louis Agassiz." He leaves behind a vast number of students who feel equally keenly that Professor Shaler was their master and who will reverence his memory as they will never forget his example or lose the influence of his inspiration.

RICHARD ELWOOD DODGE.

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RECENT PUBLICATIONS

GEOGRAPHEN-KALENDER, 1906-1907. By Dr. Hermann Haack; pp. 571 with 16 maps. Gotha. Justus Perthes, 1906.

The fourth annual Geographen-Kalender, like its predecessors, is a necessary reference volume for geographers and should be in all first-class libraries. The current volume, besides the usual tables and statistics, includes a summary of the chief geographical events for 1905, a brief but well-arranged bibliography for the same year, short notices of the eminent geographers who died in the year under review, and a reference list of the geographical institutions and periodic publications of the world.

STATESMAN'S YEAR BOOK, 1906. By J. Scott Kellie and I. P. A. Renwick; pp. 1,604, with maps. Macmillan and Company, 1906.

The Statesman's Year Book each year becomes more indispensable as a book of reference for all, but especially for geographers, editors and teachers. It is a digest of the world's financial, economic, political and social condition, prepared in such a form as to be readily used and easily consulted. It is the one authority to which to turn for the latest information about any place or geographic fact. The edition for 1906 is especially valuable because it contains a much amplified account of the United States. For the first time each State in the Union is given separate treatment, the summary in each case being topical and including a statement of the form of government, the area and population, the schools and colleges, the courts and public institutions, the financial condition, the National Guard, the chief products and industries, the deposits in banks and a list of books of reference.

THE PHYSICAL GEOGRAPHY, GEOLOGY, MINERALOGY AND PALAEONTOLOGY OF ESSEX COUNTY, MASSACHUSETTS. By John Henry Sears; pp. 418 with map. The Essex Institute, Salem, Mass., 1905.

A very complete account of a small but geographically interesting area. An excellent illustration of the possibilities in the way of local study and publication. The author has spent many years mastering the minutiæ of his subject and becoming familiar with almost every square foot in the territory. A monument to industry and patience. Excellently illustrated and attractively printed.

GEOGRAPHY OF NEBRASKA. By George E. Condra; pp. 192. The University Publishing Co., Lincoln, Nebraska, 1906.

A brief but authoritative geography of Nebraska, "written for school boys and girls," includes the geology, climate, drainage, surface features, and economic conditions of the State. Matter well chosen and well presented. The many excellent illustrations are often of little service because poorly reproduced.

GEOGRAPHICAL GLEANINGS. By Frank R. Barrows; pp. 75. George Philip and Son. London, 1906.

Includes two parts entitled, On Some Methods of Teaching Geography and On the Preparation and Teaching of the Subject. Suggestions for Fellow Teachers.

The second part is a good summary of the necessary training and point of view of a good teacher of geography and includes valuable suggestions as to equipment. The author summarizes his propositions by a series of outlines of lessons on India. Practical, suggestive, stimulating.

A PROGRESSIVE COURSE OF COMPARATIVE GEOGRAPHY ON THE CONCENTRIC SYSTEM. By P. H. L'Estrange; pp. 146, including 172 maps. George Philip and Son. London, 1906.

A combined atlas and text-book, exploiting how to teach geography "to stimulate the learner's reason rather than to train his memory." Divided into two parts, the first including the Principles of Geography and the second being devoted to Regional Geography. In each subdivision of the second part a definite causal order is followed working from the general to the detailed. The special feature of the book, as compared with its English rivals is the large number of excellent maps so arranged as to be used as a basis for a causal study of the subject matter. These maps are of good scale, clear and pleasing. They are worthy of being used for reference by American teachers. Each chapter is divided into three parts so as to be adaptable to students of different stages of advancement. The plan is such that the book cannot well be used as a text outside Britain, but as an example of progress and of a rational method of teaching geography to advanced pupils it deserves favorable commendation and wide usage.

A REAL KNOWLEDGE OF GEOGRAPHY.

A real knowledge of geography embraces at once a knowledge of the earth and of the dwellings of man upon it. It stretches out one hand to history and the other to geology and physiology. It is just that part in the dominion of knowledge where the students of physical and of moral science meet together. Let one understand the real geography of a country, its organic structure if I may so call it; the form of its skeleton, that is, of the hills; the magnitude and course of its veins and arteries, that is, of its streams and rivers; let one conceive of it as a whole made up of connected parts; and then the position of man's dwellings, viewed in reference to these parts, becomes at once easily remembered, and lively and intelligible besides.

THOMAS ARNOLD.

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NOTES

"Analysis of the Commerce of the United States with the Various Countries of the World."—"Analysis of the Commerce of the United States with the Various Countries of the World" is the title of a monograph just issued by the Department of Commerce and Labor through its Bureau of Statistics. The purpose of this monograph, as the title implies, is to show the articles forming the trade with each country of the world, article by article, during a term of years. The tables show the principal articles forming the imports from and exports to each country in each year from 1895 to 1905. The foreign commerce of the United States has grown during that period from 1,540 million dollars to 2,636 millions, an increase of 71 per cent; the imports have grown from 732 millions to 1,118 millions, an increase of 53 per cent, and the exports from 808 millions to 1,519 millions, an increase of 88 per cent.

Considering the growth by groups of articles, the figures show that the importation of food and live animals increased 17 per cent during the period named; crude articles for use in manufacturing, 93 per cent; articles manufactured wholly or partially for use in manufacturing, 72 per cent; articles manufactured ready for consumption, 19 per cent; and the group entitled "Articles of voluntary use, luxuries, etc.," 58 per cent. In exports, the group entitled "products of agriculture," increased 48 per cent; manufactures, 196 per cent; products of mining, 175 per cent; products of the forests, 117 per cent; products of the fisheries, 36 per cent, and the group entitled "Miscellaneous," 66 per cent.

Considering the commerce by grand divisions, trade with Europe shows an increase of 41 per cent in imports therefrom and 63 per cent in exports thereto; in the trade with North America the imports increased 70 per cent and the exports 140 per cent; with South America the imports increased 34 per cent and the exports 70 per cent; with Asia the imports increased 109 per cent and the exports 642 per cent; with Africa the imports increased 58 per cent and the exports 162 per cent, and with Oceania the imports increased 46 per cent and the exports 152 per cent.

It is in the details of trade by articles with the various countries of the world that the statements are especially interesting and important. They show the principal articles forming the trade with each country in each year during the period in question (1895-1905). The United Kingdom stands at the head of the list of the countries from which the imports are drawn and also at the head of the list to which the exports are sent.

The imports from the United Kingdom, which amounted to 172 million dollars in 1905 increased only 13 million dollars, or about 8 per cent, during the decade. Manufactures of fibers, cotton, wool, silk and iron and steel are the largest items of the imports from the United Kingdom, and in many of the items under these heads there are considerable increases in 1905, as compared with 1895, but in others there are marked decreases.

On the export side the United Kingdom also heads the list with an increase of 136 millions, a gain of 35 per cent during the period. Cotton, breadstuffs, provisions and cattle, lumber and timber, and manufactures of iron and steel of various kinds, copper, etc., form the largest items in the export trade to the United Kingdom, and in practically all of these there is a growth during the decade, especially in the later forms of iron and steel manufactures, such as electrical machinery, metal-working machinery, typewriters, and builders' hardware.

Germany stands second in the list of countries from which imports are drawn, the total having grown from 81 millions in 1895 to 118 millions in 1905, an increase of 37 millions during the decade, or 46 per cent. The most important articles imported from Germany are chemicals and dyes, cotton manufactures, iron and steel manufactures, paper, and the manufactures of wool, silk, cotton, and fibers, many of which show an increase in 1905 compared with 1895. The exports to Germany, which grew from 92 mlilions to 194 millions, an increase of 102 per cent during the period in question, consist chiefly of raw cotton, breadstuffs, provisions, manufactures of iron and steel, mineral oils, copper and other articles of this character, nearly all of which show a growth during the decade.

Brazil ranks third in the statement of imports, the value of importations from that country having grown from 79 millions to 100 millions during the period in question, the principal articles forming this large total being coffee and india rubber, while the exports to Brazil show a loss during the period, having amounted in 1905 to but 11 million dollars against 15 millions in 1895. Canada stands third in the list of countries to which exports are sent, the increase during the decade being about 88 millions, or 166 per cent, while the imports from Canada show an increase of 71 per cent during the same period.

Exports to China and Japan show a larger per cent of increase than to any other of the principal countries, the total value of exports to China having grown from 3½ millions in 1895 to 53½ millions in 1905, an increase of about 1,400 per cent, while to Japan the increase is from 4½ millions to 51½ millions, a gain of about 1,024 per cent. The exports to Mexico show an increase of over 200 per cent and those to Cuba and to

Australia also about 200 per cent each. On the import side the importations from Mexico show an increase of 197 per cent, from Netherlands and Belgium 155 per cent, from India 152 per cent, Cuba 63 per cent, France and Germany 46 per cent each, and those from the United Kingdom an increase of 8 per cent.

TIERRA CALIENTE.—The Tropics of Mexico, or what is termed the Tierra Caliente, embrace about two degrees of latitude. There exist three districts or marked zones of vegetation, whose limits agree in general with the variation of the soil, or in some of the other physical agents, that influence the development of the vegetable species.

In traversing from north to south the first zone encountered extends from the shores of the Atlantic (Gulf of Mexico) to the foothills. The second zone comprises the mountain region, and the third zone extends from the southern limit of the mountainous region to the Pacific Ocean.

The first zone is characterized by the grandeur and variety of the forms of vegetable life. It can be said that as a whole it is an uninterrupted forest (except in certain portions). The plants which constitute the vegetable life are in the majority of a tree-like nature and are conspicuous for the development of their trunks and ramifications.

The innumerable species of reeds and creeping plants, that entwine themselves in a thousand different ways among large, tree-like plants, make an entrance to this exceptionally fertile region almost impossible in the broadest sense of the word. The aspect of this forest is always gay and very verdant and is not affected by the change of season.

Everything in this zone reveals abundant nutrition and circumstances highly propitious for the development of the organized beings of the vegetable kingdom.

In the second, or mountainous zone, the vegetation has lost its tropical characteristics which mark the two opposite zones, as is proven by the presence of oak and pine timber, although the vegetation of the intermediate zone is highly exuberant, and the forests are more or less accessible, because the number of creeping plants, the principal obstacle to the entrance of the forest of the first mentioned zone, has diminished in a notable manner.

In the third zone, which comprises the plants of the Pacific, the vegetation by no means presents the grandeur of the plains of the Atlantic or Gulf zone, although the temperature is essentially tropical. Many circumstances which influence the development of the vegetation are here wanting.

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It will be noted that the stately trees with their dark-green foliage have been replaced by the bluish mimosas, and other plants of the fiber family. In this zone the phenomena of vegetation are also paralyzed during a large portion of the year—not on account of the cold, which is never felt in this zone, but on account of the great drought that exists during the three winter months, and the first and second months of the spring.

The cause of the difference just mentioned in the three zones is principally to be found in the manner in which the physical agents of the vegetation act in each of the above zones, the nature of the soil, exposure, degree of temperature, humidity, etc.

The long chain of mountains, that crosses the two Americas in its length, and traverses the Tropics, affords passes connecting the two oceans. The southern slopes of these mountains are very steep, while on the contrary the northern slopes gradually descend toward the plains of the Atlantic.

The predominating winds are from the north and northeast on account of the currents of the Gulf of Mexico, and the difference of temperature to be found in the plains at either extremity, and the north-northeast winds predominate all the year. The temperature on the south side is higher than on the north side, with the exception of April and May, in which the south winds blow quite freely.

The medium temperature in the different regions of the Tropics of Mexico differs more than one might expect, taking into consideration only the variations of altitude and latitude. The Pacific zone has a higher temperature than either of the other two, not only because of its direct exposure to the south, but because it is protected towards the north by the chain of mountains, which form a natural wall, and on account of other particular circumstances which cause it.

Its vegetation is more or less languid during the greater portion of the year. The plants are almost naked and permit the rays of the sun to penetrate the soil which absorbs them and in part reflects them toward the atmosphere, the dryness of which is in contrast with the two other regions of the tropics.

Although the winds that almost constantly blow from the north and northeast tend to somewhat lower the temperature of this zone, their influence is less than it should be because of vapor with which they are loaded on entering the tropics, which they gradually lose in the form of rain in traversing the plains of the northern slopes of the mountains. The small amount of humidity which the air retains, on entering the dry

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atmosphere of the Pacific plains, far from precipitating, rises and quickly scatters in proportion to its progress in said plains.

It is frequently seen that an abundance of rain falls on the northern side of the mountains while not a drop falls at the foot of the southern slope of this mountain chain.

The temperature of the plains of the Pacific is very uniform. The monthly average temperature runs from 77° to 85° Fahr. and is from 8° to 11° Fahr. higher than on the Atlantic or Gulf coast.

In the Tropics of Mexico there seems to be an average change of about 1.8° Fahr. either higher or lower, as the case may be, for each 60 feet of altitude.

In the same degree with the temperature the quantity of rainfall varies in the natural divisions of the tropic; the months of the rainy season are when he sun is north of the Equator. The summer months are termed the rainy season. However, during the "northers" that blow down the coast, it rains with more or less frequency on the plains of the Atlantic and in the mountainous portion of the Tropics.

Usually what is termed the rainy season begins early in June and ends in October. The rainfall is the heaviest and most frequent during the night time and is in the form of heavy showers, then clearing up bright and sunny; while in the winter time, when the "northers" prevail and produce a rainfall, the rains are steady and may last one, two or three days in succession, accompanied by heavy clouds.

The plains of the Pacific constitute one of the regions in which it rains but little. The rainy season is from June to September. Even during this time the rain is not so frequent nor as abundant as in the Atlantic zone.

To the difference in the climate in the three great natural divisions of Tropical Mexico there must be added the difference existing in the nature of the soil.

On the Atlantic slopes the rainfall washes down refuse from the mountains, which, with the layers of vegetable mold provided by the constant decomposition of vegetable matter which is naturally to be found on the surface of the soil, forms a layer of ground from eight to fourteen feet in depth, very rich in the organic principles which form the principal food of the vegetable kingdom.

In the central division of the Tropics the soil is sandy in some parts and loamy in others and almost as rich as in the region first described. The richness of soil is particularly noted in the mountains, where the exuberant vegetation preserves the ground constantly in a humid state.

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The exposed parts are more or less sterile and are best suited for growing certain species of grasses which form the principal feed for cattle, which thrive in this zone. On the plains of the Pacific Coast the soil is sandy and slightly loamy, which in the larger part is accompanied by a certain quantity of lime on the river banks, overflowed lands and other parts where the water is deposited during the rainy season. The layers of vegetable humus, not so thick or as rich in organic matter as in the Northern zone, are generally thinner and contain less fertilizing strength in proportion to the minor quantity of vegetable and animal matter to be found here in deposit.

Although these plains are situated almost at sea level, like the plains of the Atlantic, and are also crossed by divers streams, these latter do not cause inundations, which annually leave behind them great quantities of highly fertile land, as is the case in the Atlantic zone. The reason for this is to be found in that the quantity of water these rivers receive is smaller than that received by the streams of the northern slope of the mountains, and because their beds are not as narrow as those of the Atlantic, and because the filtration which takes place on account of the nature of the soil is so considerable that a river of medium size completely dries out during the months of April and May, up to about eight or twelve miles of its mouth. With the exception of the river Tehuantepec, which flows directly into the Pacific, all the others flow into the interior lakes of that region, some two or three miles from the Pacific Ocean, so they traverse but a short distance of the plains.

Heat and humidity, the principal agents of vegetation, work incessantly and with great intensity on the plains of the Atlantic. The soil is always conserved in a humid state, not only on account of the water, which falls in the form of rain during the greater number of months of the year, but also deposited, in the form of dew, upon the bodies to be found in free air. The abundance of the latter is particularly notable in the hottest months of the year, during which time its formation is greatly favored by climatic conditions. In reality, during these months, the sky is generally clear and the nocturnal irradiation produces a fall in the temperature in these bodies which have a considerable power of emission, as, for example, a kind of vapor of water contained in the air condenses on the leaves of plants. In the north and center of the Tropics, this condition is sufficient to irrigate and keep the ground from becoming absolutely dry, even during the winter time when the rainy season is over. The uninterrupted action of heat and humidity brings with it the continuity of the phenomena of nutrition, the immediate consequence of which is the incessant forma-

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tion of the elementary organs. These agents must produce a rapid growth and development in the plants under their influence. The luxurious foliage, constantly shown by the plants of the Atlantic Zone, the thickness and height attained by their trunks, are proof that the nutritious sap flows without cessation, the robustness of the vegetable kingdom being the best testimony. The tree growth in this portion of the tropics is most excellent for construction. They grow to very great dimensions, as shown by the large canoes made from the single trunks of trees, which form the native means of river transportation. The mahogany, cedar, rosewood, the dye woods and many other hard and soft woods, of which many are practically indestructible when set in the ground, grow in the Tropics, as well as the full equivalent of the hard and soft woods of the countries around the Great Lake regions of the Northern portion of the continent which are so greatly in demand in the manufacture of vehicles, furniture and finishing woods.

With the exception of the sandy shores of the Gulf of Mexico the entire plains of the Atlantic are formed of alluvial soil, extraordinarily fertile and suitable for the cultivation of all tropical and sub-tropical products adapted to this climate.

These plains are only awaiting the hand of man, in order to recompense him on a very ample scale for any toil or capital he may invest.

In the center or mountainous region the humidity exercises the same influence as in the northern region, but not so the heat, which works here with less intensity, owing to the difference in temperature before mentioned. The vegetation loses its tropical character. The oak and pine here take the place of the mahogany and cedar. The pine, on account of its great development and length of trunk, furnishes magnificent ship masts, and is likewise advantageously employed in all kinds of naval construction. The predominance of the pine and oak is so much more noticeable for the reason that these species grow together, occupying tracts of large dimensions.—*Modern Mexico.*